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INSTRUCTIONAL STRATEGIES FOR VOCABULARY DEVELOPMENT
IN THE CONTEXT OF A PRESCRIPTIVE MODEL

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The model on which this research is based proposes that an instructional strategy has a direct effect (on the objective it is directed toward) and indirect effects (on related objectives). Most training situations aim at teaching a group of related objectives. Following the recommendation of current learning theory, a maximally effective training sequence would consist of a separate instructional strategy to teach each objective. This is costly in time. The model suggests that it might not be necessary to use a separate strategy to train each objective if indirect effects allow us to achieve more than one objective at a time. Accomplishing more than one objective at a time results in more efficient training.

Seven objectives associated with mastering vocabulary concepts were identified and an instructional strategy designed for each. Two of the strategies were tried-out. Early results show that some methods produce high levels of achievement on more than one objective. The goal of our continuing research is to select the most efficient combination of strategies that will produce the desired high levels of achievement.

Instructional Strategies for Vocabulary Development in the Context of a Prescriptive Model[1]

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SUMMARY

This program of research has set out to address the issue of efficiency in instruction in teaching vocabulary concepts. There are a number of performance outcomes associated with "knowing" a word; we have identified seven such outcomes and have developed seven instructional modules, one targeted toward each outcome. Instruction of this sort should be effective, but not necessarily efficient, in the sense that a great deal of learning time would be spent going through each of the seven modules in order to learn each outcome. We hypothesize that it is not necessary for subjects to receive instruction via all seven modules in order to achieve acceptable levels of performance on the criterion tests measuring each outcome. We hypothesize (in a quantitative representation of the design problem) that each instructional module will have a direct effect, shown by performance on its related criterion test, and that it will also have an indirect effect, smaller than its direct effect, on the criterion tests measuring the other learning outcomes. If this is true, some smaller combination of teaching modules than the full set should produce acceptable levels of performance on the outcome measures, at a lower cost. The purpose of our program of research is to evaluate the hypothesis and to determine the optimal combinations of modules to teach vocabulary concepts should the hypothesis be confirmed.

The seven instructional modules are described in the report, in terms of their instructional routines; i.e., the sets of stimuli,

responses and feedback each contains. The rationale for each module is presented, citing whether the module evolved from an instructional design point of view or whether it is an application of psychological theory.

To achieve relatively tight control over student learning processes, a CAI (Computer-Assisted Instruction) mode is desirable to instrument the research. We have accepted delivery of two VT-52 DECSCOPE terminals and two sets of Vadic Corp. modems.

The first stage of research requires calibrating the size of the direct and indirect instructional effects; later stages will require studying how the combined use of the methods confirms or disconfirms the decision theory equations for optimal combinations of modules. In summary, the main accomplishments to date of this research endeavor include: 1) A formalization of the decision theory framework that guides this research; 2) Descriptions of the seven instructional modules and a rationale for each; 3) The introduction of a cognitive psychology perspective on the design research so as to aid understanding of learning; 4) The detailed design of the seven instructional modules plus the pretest; 5) Development of the instructional database for 24 words for six of the modules; 6) Design of the criterion tests; and 7) Preliminary testing of the effectiveness of two of the instructional modules.

A tryout of the DEFINE and CLASSIFY modules (in adapted pencil and paper form) was conducted to determine the existence

of indirect effects. All of the instructional routines making up each module were used. Twelve students were assigned randomly to each of two instructional groups. Comparison of data obtained on six of the post-tests showed evidence of indirect effects. When the quality of performance on three post-tests was compared with the quality of performance on the post-test that matched instruction it appeared that Define instruction led to greater indirect effects than Classify instruction. The differences were not statistically significant but the trends suggest different sized indirect effects for different modules and this will be one of the questions relating to optimal combinations of modules which will be pursued in forthcoming studies. We have also decided to assess indirect affects under conditions of instructional treatments with pre-defined proficiency levels rather than under conditions defined in terms of a fixed amount of time or number of items.

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The Setting and Development Objectives

The CAI development that we wish to report in this paper is directed toward enhancing vocabulary knowledge of low-verbal skills college students. The instructional design of the CAI system is a simple pretest, instruction, posttest design. The words to be taught have been selected from existing frequency lists with special attention to their "power" (occurrence in a wide range of reading materials). The sites at which the instruction will be used will be developmental reading laboratories at the campuses of a university and/or a community college.

In this paper, we wish to report the progress we have made on the design of our CAI system and the results of two studies that have helped us sharpen the methodology of our instructional research in vocabulary and that have provided preliminary information on the relative effectiveness of two of the instructional modules.

Theoretical Framework and Research Objectives

We are developing a variety of strategies for instructing the words that, according to the pretest, a given student may need to learn. Some of the strategies we have built are similar to those found within developmental reading materials; others are quite different (see later section for detailed description of the strategies). We have specified a number or performance objectives as the goals of our vocabulary instruction

and each of the strategies is focused on one of these performance objectives. Our objectives (O_i) refer to terminal behaviors such as being able to define a word, use it in a sentence, classify instances of the word properly and so forth.

There are some particularly intriguing aspects of our instructional situation. Previous research (e.g., Johnson and Stratton, 1966) has shown that one of the likely characteristics of several of our instructional strategies is that they may provide more instructional returns than one might ordinarily expect. It is likely that a given strategy will have an effect on the objective it is directly related to <u>and</u> on other objectives. Each of our instructional strategies, therefore, appears to contribute to the acquisition of more than one objective. Thus, we might restate the matter by saying a strategy has both a <u>direct</u> effect (on the objective it is directly related to) and an <u>indirect</u> effect (on other objectives). The interesting problem as we see it is to develop rules for deciding the best mix of strategies, when certain levels of achievement on tests of the objectives are desired. The rules, of course, would be formulated to take into account both the direct and indirect effects of the given strategies. The rules will also take into account the instructional "costs" associated with given individual modules or combinations of modules. We currently view "costs" to be amount of student time.

In collaboration with Guy Groen, we have developed a quantitative representation of the design problem we face and it takes the following form:

1. There are n learning outcomes, O_i (objectives).
2. For each O_i, there exists a method M_i and a criterion test, CT_i.
3. M_i yields a higher score on CT_i than M_i does on CT_j.

   Comment: This assumption reflects the admonitions of Gagné and others that instruction that is highly consistent with tests that measure its effects leads to greater achievement than instruction that is less consistent. We shall drop the assumption if it does not hold in our particular application. This will in turn mean that we can allow arbitrary selection of M_i's when composing prescriptions.
4. Each M_i has an associated cost, c_i.
5. Each CT_i has a lower bound of acceptable performance, lb_i.
6. Each M_i has a direct effect $\sigma_{ij} > o$ on CT_i and an indirect effect $\sigma_{ij} > o$ on each CT_j $(j \neq i)$ such that

$$CT_i^{\{S\}} = \sum_{j \varepsilon S} \sigma_{ij}$$

   when S is the set of methods being used.

Comment i: The σ_{ij}'s are supposed to be fixed effects. Thus, CT_i varies depending on which σ_{ij}'s are in the linear combination.

Comment ii: Equation (6) is to be considered locally acceptable.

Clearly, as the formulation shows, the central problem for this stage of our research is how to determine the σ_{ij}'s, since they are the determiners of level of achievement on a given criterion test. We are adopting two approaches to determining the σ_{ij}'s. One approach we call bottom-up, which means that we shall determine the σ_{ij}'s from the pattern of criterion test scores that are obtained after students receive instruction via a given set of modules. The second approach we call top-down and it assumes that each of the modules has a structure that can be denoted in various ways. One model of structure that we have worked out so far involves simply decomposing the modules into their instructional routines. Each module can be analyzed into component routines serving different psychological functions, and some routines are common to some modules.

Both approaches, bottom-up and top-down, lead to interesting testable predictions about patterns and levels of achievement on the criterion tests as a function of what modules are used in the students instructional prescription. We shall not explore the full set of predictions that can be generated from the model

here; we shall, however, show one interesting consequence of (6) on the previous page. It is possible to derive the theorem:

$$7. \quad CT_1^{\{1,2\}} + CT_2^{\{1,2\}} > CT_1^{\{1\}} + CT_2^{\{2\}}$$

The theorem can be shown to be true in this manner:

$$CT_1^{\{1\}} = \sigma_{11} \text{ and } CT_2^{\{2\}} = \sigma_{22}.$$

Thus,

$$CT_1^{\{1\}} + CT_2^{\{2\}} = \sigma_{11} + \sigma_{22}.$$

But,

$$CT_1^{\{1,2\}} + CT_2^{\{1,2\}} = \sigma_{11} + \sigma_{22} + \sigma_{12} + \sigma_{21};$$

and so,

$$CT_1^{\{1,2\}} + CT_2^{\{1,2\}} > CT_1^{\{1\}} + CT_2^{\{2\}}.$$

The above theorem is tested in an experiment comparing student achievement summed on two criterion tests as a function of instructional modules (1 or 2 only vs. 1 <u>and</u> 2) received. Our research in the forthcoming months will be directed toward testing theorems such as (7). We shall initially be concerned with developing our prescriptive rules as they apply to groups of students; eventually we hope to be able to apply the formulation we have developed to the learning of individuals, for one might reasonably expect individuals to differ in their propensity to

transfer (i.e., the magnitude of indirect effects ought to vary among individuals).

Exploration of the previously described model that we think governs construction of instructional prescriptions in vocabulary shows that it has some interesting consequences. The key concept of the model is the existence of indirect effects. If indirect effects do not exist, then the question of what constitutes the most appropriate prescription is uninteresting, because in order to develop each one of a set of performance objectives, each of the methods must be used. Therefore, the major purpose of the first stages of our research has been to demonstrate that indirect effects exist. Of course, to enhance the chances that the methods we develop do in fact produce indirect effects, we have incorporated the methods used in the 1966 study which were, in turn, based upon methods found in the developmental reading literature.

Our purpose in this paper is to describe the seven instructional modules we have developed in terms of the design guidelines used to create them and in terms of their component routines. We also include displays of the instruction as it will appear on the CRT, for visual displays show instructional task content in ways that are not easily captured in text descriptions. We shall also describe some research of a preliminary nature that bears on the question of the existence of indirect effects.

The Instructional Modules

This section will describe the DEFINE, CLASSIFY, WORD RELATIONS, WORDS IN CONTEXT, WORD LINE, DISCOVER and EQUIVALENTS modules. Each module comprises smaller segments of instruction called routines - each routine corresponding to a change in the stimulus-response situation. The routines were designed to follow a shaping procedure, i.e., gradually reducing the stimulus support for the terminal response as the module procedes. Routines are of two kinds: expository and inquisitory. Some routines occur in more than one module. Table 1 lists and briefly describes all routines for all seven modules and can be consulted to compare them. It will be noted that some routines use a response contingent criterion for exit; others do not.

Insert Table 1 about here

Define Module

The define module consists of seven routines.

Routine 1: Pronounce. This routine presents the target word and a phonetic pronunciation key, with the direction to the student to pronounce the word. This routine begins six of our seven modules.

Routine 2: Definition. An extended definition of the target word is shown, emphasizing the critical attributes by separating them visually from the rest of the display. The student is instructed to read the definition.

TABLE 1

Modules and Their Component Routines

DEFINE	CLASSIFY	DISCOVER	WORD RELATIONS	WORD LINE	WORD IN CONTEXT	EQUIVA-LENTS
1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Pronunciation (Exp.)	1. Multiple Choice (Inq.)
2. Introductory Definition (Exp.)	2. Introductory Definition (Exp.)	2. Introductory Examples (Exp.)	2. Introductory Definition (Exp.)	2. Introductory Definition (Exp.)	2. Type from Memory (Inq.)	
3. Type from Memory (Inq.)	3. Example/ Nonexample (Inq.)	3. Forced Choice of Example (Inq.)	3. Forced Paraphrase (Inq.)	3. Forced Paraphrase (Inq.)	3. Story (Exp.)	
4. Definition with Attribute Labeling (Exp.)	4. Forced Choice of Example (Inq.)	4. Practice (Inq.)	4. Type from Memory (Inq.)	4. Type from Memory (Inq.)	4. Type Word (Inq.)	
5. Multiple Choice Paraphrase (Inq.)	5. Forced Choice Example Summary (Exp.)	5. Illustrative Definition (Exp.)	5. Explanation of Relations (Inq.)	5. Illustrative Line (Exp./Inq.)	5. Questions (Inq.)	
6. Multiple Choice Definition Construction (Inq.)	6. Practice (Inq.)		6. Practice Relations (Inq.)	6. Map Line (Inq.)	6. Type Word (Inq.)	
7. Definition Construction (Inq.)			7. Relations Summary (Exp.)	7. Rate Line (Inq.)	7. Sentence Completion (Inq.)	
				8. Line Summary (Inq.)		

Routine 3: Type from Memory. While the definition remains on the screen the student is instructed to look carefully at the word until ready to type it from memory. The student then types the word after the stimulus disappears from the screen. Feedback either confirms a correct response or - in the case of an incorrect response - presents the word again, which is retyped by the student with the word in view. (Figure 1 presents screen displays for DEFINE, Routines 3, 5 and 6).

Insert Figure 1 about here

Routine 4: Definition with Attribute Labeling. First the form class of the target word is identified along with a general statement of what a definition of this form class should consist of. Then a short form of the target word's definition is presented with the parts labeled according to the preceding statement.

Routine 5: Multiple Choice Paraphrase. In this routine part of a definition paraphrased from the original definition appears on the screen; it is incomplete because one of the critical attributes is left blank. The student selects from three choices the paraphrase of the missing critical attribute. Feedback for an incorrect response tells the student to pick again. This routine is repeated for the number of critical attributes contained in the target word.

In this routine an option is introduced. The definition from Routine 4 can be either present or absent while the multiple

DEFINE

Routine 3: Type word from memory

> Sometimes, you may meet a person who attempts to win favor or advancement by flattering persons of influence. This kind of person who wants to get ahead by soft-soaping is called a SYCOPHANT.
>
> Thus, a SYCOPHANT is: a person
> who tries to get ahead
> by buttering up
> influential people.
>
> Study the new word.
>
> Press return when you are ready
> to spell it from memory >

Routine 5: Multiply choice paraphrase of each of the definition's critical attributes

> Pick the phrase that correctly restates
> part of the definition.
>
> A sycophant is: anyone
> who tries to (**??**)
> by apple-polishing people in control.
>
> 1) improve his or her position in life 2) help other people 3) hurt his or her friends
>
> Type its number >

Routine 6: Multiple choice paraphrase of all critical attributes

> A sycophant is (GEN CLASS) who tries to
> (SPEC QUAL 1) by (SPEC QUAL 2).
>
> SOMEONE — HARM HIS FRIENDS
> ANYTHING — BE HELPFUL
> ANYONE OR ANYTHING — BECOME SUCCESSFUL
>
> PRAISING POWERFUL PEOPLE
> WORKING HARD
> BORROWING
>
> Complete the definition by typing the
> correct key terms. Press return after
> each key term.
>
> A sycophant is >

CLASSIFY

Routine 3: Matched Example and Non-example

> This is an EXAMPLE of a sycophant:
> a starlet buttering up a well-known film director
> in order to get a leading role
>
> This is NOT AN EXAMPLE of a sycophant:
> a starlet dating a film director because
> she likes him
>
> In which instance is the starlet trying to get a favor?
>
> Type EXAMPLE or NONEXAMPLE. >

Routine 4: Forced choice of example

> One of the instances below is an example of a sycophant.
> The other is not.
>
> 1) a handsome young man complementing an older woman because he respects and admires her
>
> 2) a handsome young man flattering a rich older woman in order to be written into her will
>
> Type the number of the instance that is an example. >

Routine 6. Practice

> If this instance is an example of a sycophant, type the
> word: SYCOPHANT. If it is not an example of a
> sycophant, type: NOT A SYCOPHANT.
>
> A second-string football player apple-polishing the
> coaches in order to get a starting position on the team
>
> >

Figure 1. Simulated screen display for DEFINE and CLASSIFY.

choice paraphrasing occurs in Routine 5. This and other options in other modules allow for variability in what we believe to be important instructional parameters. These options allow us to make some modules more similar or less similar to each other and to isolate parameters that theoretically might produce significant differences in achievement.

Routine 6: Multiple Choice Definition Construction. In this routine the general statement of the form of the definition (from Routine 4) is given. The student selects a correct paraphrase (different from those in Routine 5) for all of the parts of the definition. This routine thus begins to approximate definition construction. Feedback for an incorrect response directs the student to try again. After two incorrect responses, the correct definition is shown.

Routine 7: Definition Construction. In the final routine of this module the student is instructed to type a definition of the target word. She/he is cued to start by typing the target word and to phrase the definition appropriately for a word in its form class. After making the response, the student compares his or her definition with a presentation of the original definition.

The criterion test for this module is similar to Routine 7, definition construction, minus the feedback.

For the remaining modules only those routines that are different from the routines in the DEFINE module will be described.

Classify Module

Routine 3: Example/Non-example. After presenting the word and its pronunciation plus the definition, CLASSIFY next presents a situational example of the target word and a matching non-example that differs from the example on only one attribute. Example and non-example are labeled and a question is asked which requires the student to attend to the presence of the attribute in the example and its absence in the non-example. The student responds by typing either EXAMPLE or NONEXAMPLE. Feedback for an incorrect response calls attention to the attribute the student should have attended to in making the response, then directs the student to choose again. This routine repeats for each attribute of the target word then a final pair is presented which varies all attributes at once. (Figure 1 presents screen displays for CLASSIFY Routines 3, 4 and 6).

Routine 4: Forced Choice of Example. Next a matched example/non-example pair of situations is presented unlabeled. The student is instructed that only one of the instances is an example of the target word and is asked to identify it by typing its number. Feedback indicates whether the response is correct or not and if not, the specific wording in the example that "gives it away" as the example is capitalized. The student chooses again. Note that in both Routines 3 and 4 the student must make the correct response before receiving the next item.

This routine is repeated until a total of six or seven example/ non-example pairs have been presented in both Routines 3 and 4.

Routine 5: Forced Choice Example Summary. This routine re-presents only the examples from the previous routine. They are identified as examples and the student is instructed to note how they are alike and how they differ.

Option: The short form of the definition can remain on the screen during Routines 3, 4 and 5. Having the definition on makes this module more similar to DEFINE.

Routine 6: Practice. In the final routine the student is presented with one instance at a time with the direction to type the target word if the instance is an example or type "Not (target word)" if it is a non-example. This routine is repeated four times with the instances being randomly varied between examples and non-examples with the constraint that at least one example and non-example shall appear among the four instances. Feedback for an incorrect response labels the given instance as either EXAMPLE or NONEXAMPLE and presents the matching instance. The student is directed to read and compare the two instances. This routine re-presents missed items after all items have been presented once.

The criterion test for this module is similar to Routine 6, minus the feedback and the re-presenting feature.

Discover Module

This is a discovery version of CLASSIFY, the rationale being that a task requiring the student to induce a concept from

examples might aid in the development of the critical attributes in memory. The routines are largely the same as in CLASSIFY but there are two important differences. First, the definition is not presented until the end in DISCOVER. Second, in place of CLASSIFY'S inquisitory example/non-example routine, DISCOVER has an expository Introductory Examples routine which simply presents a labeled, matched pair without calling attention to the critical attributes in the example.

The DISCOVER module then goes into the Forced Choice of Example routine, identical to that in CLASSIFY, and then into the Practice routine.

Options: The example/non-example pair from the Introductory Example routine and those pairs from the Forced Choice of Examples routine can remain on the screen throughout the latter routine. If this option is chosen, then the Practice routine is identical to Practice in CLASSIFY (the examples having been erased from the screen). If the option is not chosen then Practice takes a slightly different form. Instead of presenting only four instances to be classified and reserving their matching instances for feedback, the matching instances are included in the instance pool, thus giving four example/non-example pairs, randomly arranged. Feedback for an incorrect answer simply indicates that the answer is wrong and directs the student to try again.

The final routine presents the short version of the definition with attributes labeled.

The criterion test is the same as for CLASSIFY.

Word Relations Module

This module begins with the pronunciation and definition routines described earlier. The third routine, Forced paraphrase, is similar to the Multiple Choice Paraphrase routine in DEFINE except that instead of paraphrasing each separate attribute a paraphrase of the target word is selected. (Figure 2 presents screen displays for WORD RELATIONS Routines 3, 5 and 6).

Insert Figure 2 about here

The characteristic routines for this module begin with Routine 5, Explanation of Relations. This routine illustrates how two words can be related to each other by presenting two examples of a particular relation. The first example is an archetype of the relation, e.g., "Helpfulness is a QUALITY of a Boy Scout." The second example illustrates the same relation for the target word, e.g., "Insincerity is a QUALITY of a sycophant." The student is then directed to select another word that bears the same relation to the target word. This routine is repeated for three or four different relations. Feedback identifies the response as correct or incorrect and if incorrect, the student is directed to try again.

WORD RELATIONS

Routine 3: Paraphrase

One of these phrases captures the meaning of SYCOPHANT.

1) a hard-working achiever 2) a fast-talking apple-polisher 3) a wealthy fat person

Type the number>

Routine 5: Relations

Words can be related to each other in various ways.

For example,

if helpfulness – is a QUALITY – of a Boy Scout,
then insincerity – is a QUALITY – of a sycophant.

Fill in the blank.

(**??**) could also be a QUALITY of a sycophant.

1) honesty 2) kindness 3) ambition 4) fairness

>

Routine 6: Practice

Identify the relationship by typing the correct number.

How is charm related to a sycophant?

1) is a JOB of 2) is a TOOL of 3) is a GOAL of

>

WORDS IN CONTEXT

Routine 4: Story and Questions

King Foolish liked to be surrounded by members of his court. He spent his whole day listening to them flatter him to build up his ego.

One of the attendants, who thought he might be rewarded by the king with a purse full of gold, was full of praise. This attendant was always saying, "King Foolish, how wonderful you are! King Foolish, you're the wisest ruler a kingdom could have! King Foolish, you're the greatest!"

Another attendant wanted to be made a knight. This attendant had a slightly different approach to winning the king's favor. He was constantly kneeling before the king and kissing his hand. When the king was around, this attendant never got off his knees.

The queen watched what was going on among the members of the court. "Humph!" she snorted one day when she was fed up. "They're sycophants, all of them. Each of those attendants is about as sincere as my pet monkey."

The queen called the attendants sycophants because:

1) they buttered up the king to get favors.

2) they flattered the king to make her jealous.

3) they praised the king to make him happy.

>

Routine 8: Sentence Completion

Complete this sentence in your own words.

A student might be called a sycophant if he

Press return when you have finished.

Compare your answer with this sample answer.

A student might be called a sycophant if he flattered the teacher in order to get a high grade.

Figure 2. Simulated screen display for WORD RELATIONS and WORDS IN CONTEXT.

Option: The short form of the definition can remain on the screen during Routines 3 and 5.

In Routine 6 a word is presented along with the target word and the student selects the name of the relation between the two words. This routine continues through several examples for each of several relations, different ones from those used in Routine 5. In writing instructional materials for this module we work from a list of 15 possible relations. The list includes, for example: CAUSE of, RESULT of, TOOL of, TARGET of, LOCATION of, PART of, etc. Not all the relations are applicable to each target word, of course, but for those that apply four or five examples of each relation are written. This routine repeats for about 20 questions, presenting 2 to 4 questions for each appropriate relation. Feedback for an incorrect response identifies the answer as wrong and directs the student to try again. Missed items are re-presented at the end of the series.

The final routine, Relation Summary, lists all the relations taught for the particular target word and re-presents an example of each relation. The student is required to type the target word several times in this routine.

The criterion test is similar to Routine 6, minus feedback. Because this test is based upon a model of memory, we consider it to be experimental in nature. It will be of great interest to us to determine whether a subject receiving instruction solely

via WORD RELATIONS will reflect a difference in cognitive structure from those subjects receiving instruction via the other modules.

Word in Context

The characteristic routines in this module present a story of about 160 words and a series of six or seven questions which relate details of the story to attributes of the target word (see Figure 2). The target word appears in the story only once, toward the end. The stories are often generated from one of the examples from CLASSIFY. As an aid in generating the questions Stein and Glenn's (1977) schema for analyzing story comprehension (derived from Rumelhart) served as a guide in selecting those units of a story that are most likely to be remembered.

The questions vary in format: multiple choice, yes/no and short answer. Feedback for an incorrect response identifies the answer as wrong and directs the student to try again.

Option: The story can remain on the screen while the questions are presented. If this option is chosen, feedback for an incorrect response also includes underlining the pertinent words of the story.

The last question presented is in the form of a multiple choice sentence completion. This approximates the terminal task of the module.

The final routine requires the student to finish a sentence, the given part of which includes the target word. The

student response calls for an explanation of the word. For example, "A student might be called a sycophant if he . . ."

The criterion test for this module is sentence completion.

Word Line Module

This module is identical to WORD RELATIONS for the first four routines. The first new routine for this module, Routine 5 Illustrative Line, introduces the student to a word line, demonstrates how it is used and gives the student brief practice on the task that will follow. After having done this routine once, the student has the option of skipping it the next time he/she works through this module. (Figure 3 presents screen displays for WORD LINE Routines 5, 6, 7 and 8).

Insert Figure 3 about here

In Routine 6, Map Line, the word line presents the target word in a group with five other words of the same form class and requires the student to arrange them along the line according to some semantic dimension (usually the major attribute of the target word drawn from the definition). In Figure 3, for example, the dimension of the word line is: to make larger/to make smaller, for the target word "augment." The other words in the group include one synonym of the target word, two antonyms and two words that fall into the middle ground along the given dimension. Note

WORD LINE

Routine 5: Illustrate Wordline

Words can be linked to each other along a
word line.

Hard ⟷ Soft

For example, these words can be arranged on this line:
wood, marshmallow, glass, feather, rubber, stone

Press return to see how the words are arranged.
>

Routine 7: Rateline

1	2	3
reduce	replace	AUGMENT

Type the number of the place that
money collecting interest in a bank account
goes.

>

Routine 6: Mapline

AUGMENT can be placed on this word line.

Make Smaller ⟷ Make Larger

Words that can go on this line:
shrink, add, reduce, enlarge, restore, augment

Pick the place on the line that shrink goes.

1) to the left 2) in the middle 3) to the right

>

Routine 8: Line Summary

shrink — replace — AUGMENT

Type the word that describes what will
happen to a person on a diet.

>

Figure 3. Simulated screen display for WORDLINE.

that the instructions avoid implying that the word line represents a continuum with subtle gradations. The task essentially requires the students to sort six words into three categories; in this case, the categories are to make smaller, to make larger and to do something that neither makes smaller nor larger. Two words go into each category and the position of the words within categories is not important. Feedback identifies the response as correct or incorrect and places the word on the appropriate section of the line.

In Routine 7, Rate Line, the student is given a short word line with the target word and one other word in each category in position on the line. Six instances are presented and the student must select their appropriate positions on the line, thus relating an instance to a word on the line.

In Routine 8, the final routine, questions are asked and the student responds with the words from the word line. This provides two opportunities for the student to write the target word (plus the earlier opportunity in the Type from Memory routine). The criterion test for WORD LINE is similar to Routine 6, the student arranges the target word and five other words on a line.

Equivalents Module

The Equivalents module is a very simple comparison module. It consists of a single routine which presents repeated practice

on items missed on the multiple choice pretest. The format is the same as on the pretest except for feedback. Confirmation is given following a correct response; in case of a wrong response, the correct answer is identified. Items continue to be re-presented until the student has responded correctly a given number of consecutive times. The option for this module is that the number of consecutive correct answers required may vary. An important feature of this module is the use of an item presentation strategy that attempts to maintain a lag of three interpolated items between a word's $n^{\underline{th}}$ and $(n + 1)^{\underline{st}}$ presentation.

Insert Figure 4 about here

Figure 4 illustrates the computer management of the instructional system. The left column (Input) refers to the various computer programs that process the instructional material for presentation to the student on the DECscope. The output program collects and prints out the student response data. The Student Use Package refers to the programs that test the student and present the words missed on the pretest for instruction via one or more modules.

There will eventually be two modes of system use: Instructional and Experimental. At present we are in the Experimental mode. In this mode the experimenter specifies how many words the student will learn and which module or modules will be

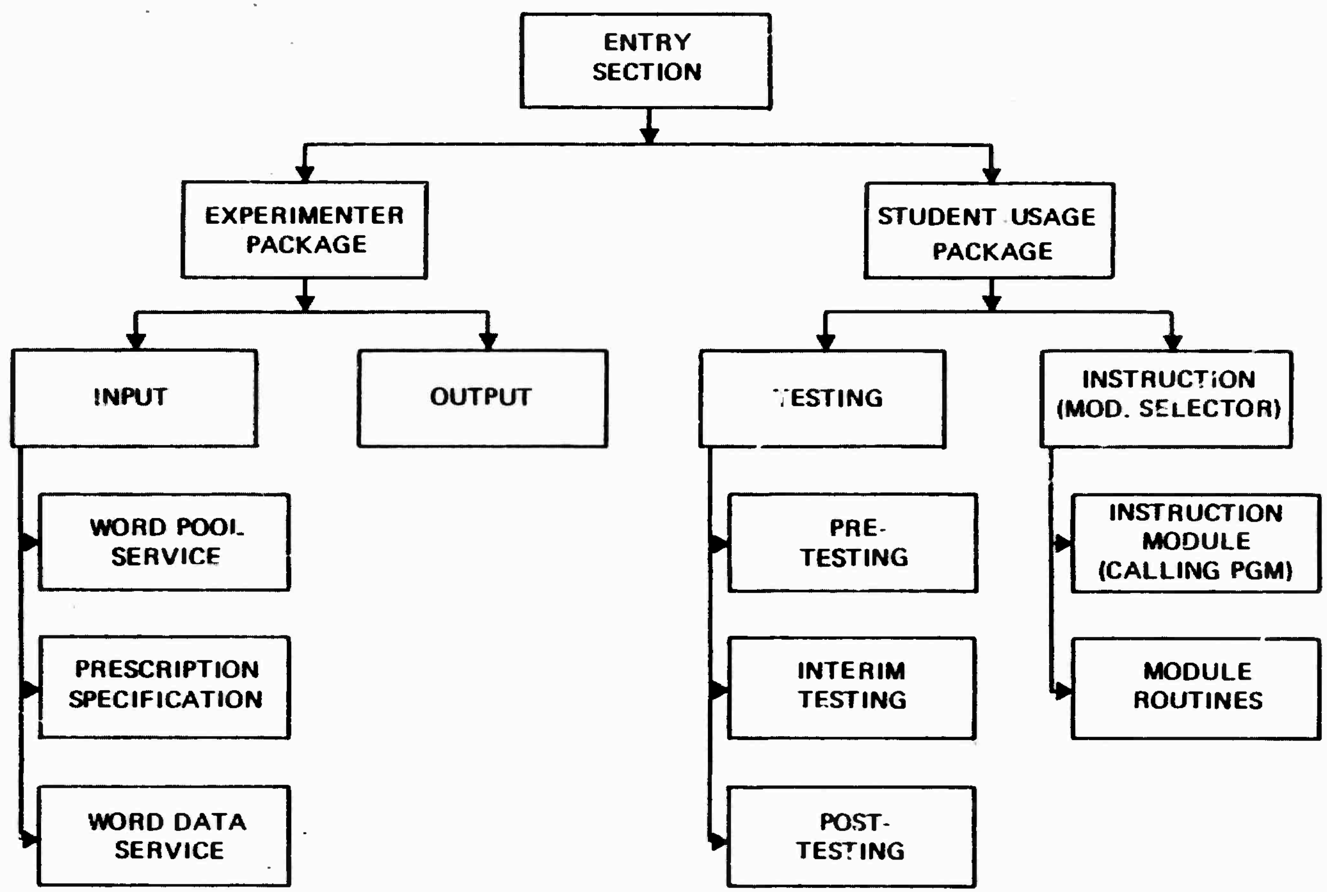

Figure 4. CAI Vocabulary Instructional System

needed for instruction. Later, in the instructional mode, prescriptions specifying combinations of modules will be developed from the experimental findings and tested for optimum achievement.

The Computer System

The vocabulary instruction is coded in Fortran IV and will be delivered via Digital Model VT-52 Video Display terminals with a 120 character/sec. transmission rate, connected to a PDP-15. The time-sharing system, ETSS, was developed at the Learning Research and Development Center (Fitzhugh, 1973). The system consists of a DEC PDP-15 computer, over 100 megabytes of high speed disk memory, and a terminal controller capable of supporting up to 32 work sites. In addition, a small DEC PDP-11 computer is attached to the PDP-15 and controls a high speed line printer, a card reader and a card punch. An on-line text editor, a comprehensive statistical package and a variety of utility systems are also provided. Several applications programers develop the instructional programs according to the specifications of the instructional designers.

Since our CAI programs are not yet completed, the studies we report were conducted with paper and pencil materials. In the second study, we attempted to achieve as much moment-to-moment control over student learning processes as was possible within the constraints of a relatively inflexible paper and pencil media.

Two Vocabulary Studies

Two studies were conducted in pursuit of determining the instructional effects of several modules.

Study I

The first study (Rosner, 1978) used materials and a procedure directly modeled upon the 1966 study noted previously that served as our initial empirical justification for the existence of indirect effects from vocabulary insturctional strategies. The purpose of Rosner's study was in part to determine whether the sizeable indirect effects found with the use of a definitions method could be replicated in our laboratory. She taught four difficult vocabulary words that were identified on the basis of a pilot study and word frequency counts to college students. Unfortunately, despite the fact that the difference between the number of words her instructional groups mastered compared to her control group was comparable to the difference between instruction and control groups in the 1966 study, her difference was not significant. Thus, it was not meaningful to discuss the effects obtained via the instruction.

We suspect that most of the difficulties of the study were procedural. First, students in the 1966 study kept the materials for 12 minutes; Rosner's students paced themselves for an average of 7 minutes with the material. Recent research on learning within CAI or CMI environments has shown that problems students

encounter center around deficiencies in self-management skills (see Judd, McCombs & Dobrovolny, 1978) and they need skill management training. It seems likely, therefore, that students simply did not manage their word study effectively. A second problem is concerned with defining an appropriate degree of control over student learning processes when only a single frame is devoted to a particular word (as was the case in the 1966 study for the definitions method). This level of instructional control over student learning processes is fairly gross; students can make the single required response for each instructional word, then attention can wander for the rest of the interval (in some students) or appropriate study behavior will take place (in others). Perhaps it is the case that the naturally occurring distribution of learner processes during a "free" period is the significant determiner of achievement and not instructional method (at least as such methods were implemented in the 1966 study). Since Rosner's learners spent a briefer time in instruction than those in the 1966 study, it is possible that had more time been required (or multiple frames per word been used) achievement might have been increased. The lack of significant differences may have been due to a higher level of prior learning of the instructional words than was expected. Finally, it is commonly found that undergraduate students are not often motivated to perform well in psychological experiments. We expect that the

responsive instruction provided by our CAI will induce more substantial levels of learning.

We improved the methodology of the second study by using multiple frames to instruct a word and the frames were modeled after two of our CAI modules. This change had the effect of increasing instructional time and theoretically, achieved more precise control over student learning processes within a given instructional interval. We also used a pretest as a method for identifying previously unknown instructional words. Thus, our second study is modeled as closely after our instructional system design as we could accomplish within the constraints of paper and pencil materials. A second constraint was that we had to use a fixed number of instructional sessions because our subjects were recruited from a small educational psychology class.

Study II

Purpose. The major purpose of the study was simply to verify the existence of indirect effects under the instructional conditions we had designed. The modules tested were those for which material had been written and tested, the DEFINE module and the CLASSIFY module (in adapted paper and pencil form). In the paper and pencil adaptation, we used all of the instructional routines that defined each module, adapted as best we could to a paper and pencil programmed instructional format. The

instructional materials consisted of a series of frames for each word that followed a shaping procedure.

Design and Procedure. Ten infrequent words were taught to two groups of students recruited from an introductory educational psychology class. There were 12 students randomly assigned to the two instructional groups. The materials for each instructional word consisted of five pages of instructional frames with response feedback typically at the top of a "next" page. Students also had to use a paper cover (laminated plastic sheet) designed to be used to cover up certain portions of the previous text material. The paper cover was our attempt to mimic the erasure capability of a CRT. The words were presented in a different random order to the students.

In the first session, students took a multiple choice pre-test requiring identification of a verbal phrase equivalent in meaning, learned the ten words (some of which they already knew as indicated by the pretest) and then took an immediate definitions post-test. It was not possible given constraints under which the study operated to teach students only the words they missed. Students returned exactly one week later for retention tests (they were not informed they would be tested). They were given six tests - free recall, definition-stating, sentence generation, sentence understanding, classification; the multiple choice pre-test also served as a post-test. The free recall test was

included because we believe modules other than the ones used in the present study will influence free recall, and we wanted a measure from the two methods of interest in this study. The tests were ordered as noted to minimize learning from one test to the next.

Results and Discussion

Time and total learning. There was a significant difference in the mean amount of time spent learning in the two groups. Mean time spent in Define instruction was slightly longer ($\overline{X}$ = 29.4 minutes) than in Classify instruction ($\overline{X}$ = 25.7 minutes), a difference of 3.7 minutes ($t = 2.40$, $df = 22$, $p < .05$). We do not, however, think the time difference is large enough to be practically significant or to strongly bias our achievement results. Our mean time per word was close to the 1966 study which used 12 minutes for four words.

The two groups did not differ in prior level of word knowledge when entering the instructional treatments; the Define group knew an average of 6.7 words, while the Classify group knew an average of 5.8 words ($t = 1.25$, $df = 22$, $p > .05$). A t test of the mean number of words gained in each group using scores on the multiple choice test (a test of general vocabulary knowledge) that was given as a pre and post-test showed both groups gained an equivalent amount ($\overline{X}$ gain for Define was 2.67; $\overline{X}$ gain for Classify was 3.10; $t = 2.074$, $df = 22$, $p > .05$). The Define group

obtained 94% (6.7 + 2.7) overall, while the Classify group obtained 79% (5.8 + 2.1). A t test of the scores earned on the multiple choice post-test showed the means were not significantly different ($t = .921$, $df = 22$, $p > .05$).

A comparison of scores on the immediate definitions test with the delayed definitions test (see scoring system, p. 30) revealed higher average immediate scores for both groups and no significant difference between the two groups in proportion of new words learned, then forgotten ($t = .549$, $df = 22$, $p > .05$). There were no differences in the number of instructional words that were recalled in the free recall test ($\bar{X}$ for Define was 4.0; $\bar{X}$ for Classify was 3.9; $t = .11$, $df = 22$). These data are decidedly consistent with the proposition that in terms of total amount of achievement, type of instructional method does not make a difference.

Indirect Effects

The concepts of direct and indirect effects require that we consider instructional methods not only in terms of contribution to an outcome of general interest but in terms of patterns of achievement across multiple specific objectives that might be desired as outcomes of an instructional program.

Insert Tables 2 and 3 about here

TABLE 2

Mean Performance on Several Criterion Tests of the Instructional Objectives. The Proportions in Parenthesis are the Comparable Figures from the 1966 Study

ALL WORDS

Method Group	Number of Subjects	Number of Words	Define			Classify			Sentence Generation		
			pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$
Define	12	10	167	240	.696 (.631)	841	960	.876 (.875)	255	360	.708 (.718)
Classify	12	10	117	240	.487 (.668)	843	960	.878 (.887)	219	360	.608 (.756)

NOTE: pts. obt. is <u>points obtained</u>
pts. poss. is <u>points possible</u>

TABLE 3

Mean Performance on Several Criterion Tests of the Instructional Objectives

NEW WORDS ONLY

Method Group	Number of Subjects	Number of Words	Define			Classify			Sentence Generation		
			pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$	pts. obt.	pts. poss.	$\bar{X}$
Define	12	40	44	80	.550	288	320	.900	70	120	.583
Classify	12	50	35	100	.350	357	400	.892	64	150	.427

NOTE: pts. obt. is points obtained
pts. poss. is points possible

Tables 2 and 3 show the mean performance on several criterion tests of the instructional objectives as a function of instructional method (the sentence understanding test is not included as we have not arrived at a reliable scoring system yet). The data are presented for all instructional words (Table 2) and for only those words learned in the course of the instruction (the "new" words [Table 3]).

The total number of points that could be earned varied from one criterion test to another. The definitions post-tests was scored 0, 1, 2 depending on number of attributes mentioned in a definition (reliability = .90; maximum points = 12x10x2 = 240); the classification test comprised 8 instances per word (maximum points = 12x10x8 = 960); the sentence generation test was scored 0, 1, 2, 3 depending on meaning and usage (reliability = .90; maximum points = 12x10x3 = 360). The data for all words in the Define group are clearly comparable to the 1966 study; there are, however, some discrepancies in the Classify group. The discrepancy in the sentencing test is easily explained; our test required complete sentence construction (using the word "because") whereas the 1966 study required sentence completion (a meaningful stem was given). There were procedural differences in concept teaching methods between the 1966 study and ours which is probably responsible for our classify students lower defining performance. The data for new words only show lowered performance on the defining

and sentencing tests as would be expected for words that students have no prior knowledge of. The pattern of levels of achievement shown for all words is reflected in the new words only for the defining and sentence generating tests. The classification test retains a high level of performance because it is an easier test. A test of the largest achievement difference (Define vs. Classify for all words) revealed no significant differences: $t = 2.006$, $df = 22$, $p > .05$. We are tempted to conclude, as was done in the 1966 study, that transfer from one instructional method to tests based on other methods is 100% and therefore we have evidence of substantial indirect effects.

Within a CAI context, however, it is standard procedure to define criteria that individuals must meet before they can exit a particular segment of instruction. Both studies, ours and the 1966 study, fixed the amount of time and material to be covered within an instructional treatment, and did not set a mastery criterion. Therefore, in order to study the indirect effects that may be associated with a particular instructional strategy, we must assess those effects contingent upon a performance standard.

Insert Tables 4 and 5 about here

Tables 4 and 5 show the quality of performance on the several criterion tests as a function of the quality of performance on the criterion test matched to the instructional method. In each

TABLE 4

Quality of Performance on the Classification and Sentence Generation Posttests as a Function of Quality of Performance on the Definitions Posttest for the DEFINE Instructional Group.

	Type of Performance on Define Post		Type of Performance on Other Posts			
			Classify		Sentence Generation	
	Number of Subjects	Frequency	Good	p	Good	p
Good	8	18	18	1.0	16	.89
Poor	5	14	8	.57	3	.21

TABLE 5

Quality of Performance on the Definitions and Sentence Generation Posttests as a Function of Quality of Performance on the Classify Posttest for the CLASSIFY Instructional Group.

	Type of Performance on Classify Post		Type of Performance on Other Posts			
			Define		Sentence Generation	
	Number of Subjects	Frequency	Good	p	Good	p
Good	12	38	10	.27	16	.42
Poor	7	12	2	.16	2	.16

instructional group for each new word and each student, the occasions on which the post-test score was excellent (a score of 2 for the definitions post; a score of 7 or 8 instances classified correctly out of 8 instances) and the occasions on which it was poor (a score of 0 for the definitions post; a score of less than 7 instances classified correctly) were noted. For these two classes, observations of the quality of performance of the same student on the same word were made on the other post-tests. For example, in Table 4, of the 18 observations of high quality definitions, there were 18 observations of high quality classification performance and 16 observations of high quality (a score of 3) sentence generation. It can be easily seen from a comparison of Tables 4 and 5 that the consistency in the quality of performance given on a defining post (Table 4) is quite different than that given on a classifying post (Table 5). The trends evident in the tables tend to show that Define instruction leads to more direct effects than Classify instruction, for high quality performances tend to be maintained to a greater degree. However, a test of the significance of the difference in the proportions using the normal approximation to the Irwin-Fisher exact test showed no significant differences ($\chi^2 = 2.39$, $df = 3$, $p > .05$). While the construction of prescriptions is more interesting when methods produce differently sized indirect effects, our preliminary data have suggested the indirect effects may be similar rather than different in magnitude.

We have, therefore, decided that within a CAI context it is more appropriate to assess indirect effects under conditions of instructional treatments with pre-defined proficiency levels rather than conditions defined in terms of a fixed amount of time or number of items. This does not negate the formulation presented previously. What we have done is to clarify the definition of indirect effects in a criterion referenced (rather than norm referenced) context. The design of our CAI system reflects this clarification: We have incorporated an interim test for each module whose format is matched to the module. Students cannot exit from a given module until the interim test is passed.

Future Work

In the near future, our research will concentrate on testing for indirect effects and testing predictions from our model, such as theorem number 7 mentioned previously. Our goal is to develop the prescriptive rules that allow us, through suitable selection of instructional strategies, to optimize a given performance function across a variety of criterion tests, within certain time constraints. As we perform our research we will, of course, be providing services to developmental reading laboratories and we are anxious to begin implementation at our planned sites.

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